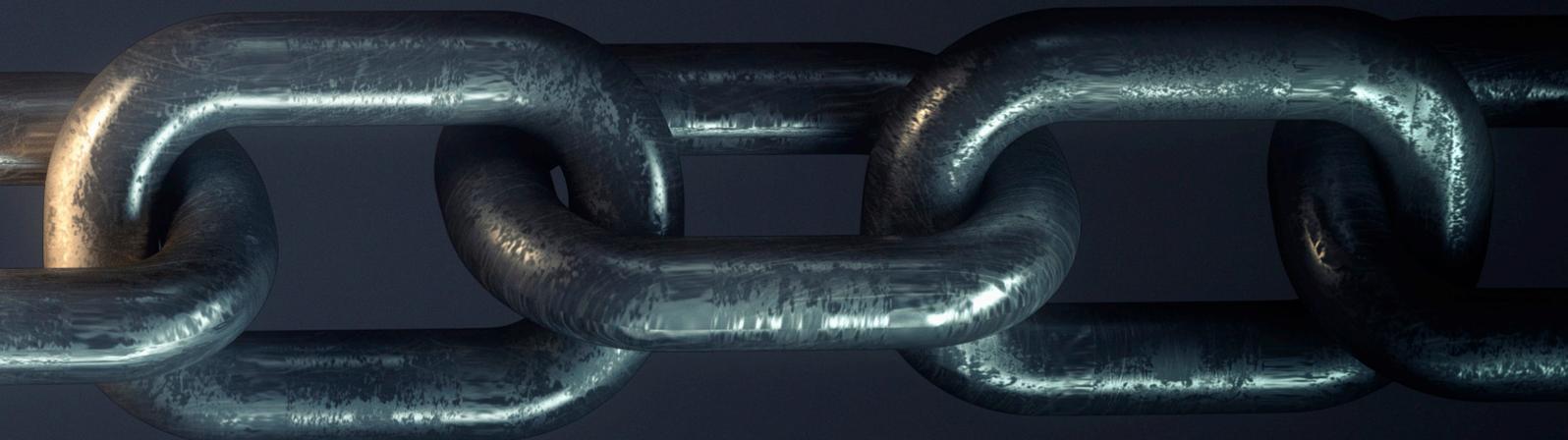
A glowing circular ring is the central focus, with a chain link passing through it. The ring and the chain link are illuminated from within, creating a bright, warm glow. The background is dark, making the glowing elements stand out. The text "A CRITICAL COMPONENT" is centered within the ring.

A CRITICAL  
COMPONENT

**Tom Hewitt, Jordan Lewis, and Stephen Forrester, NOV,** examine the use of custom solutions to the challenges of North American coiled tubing.

**A**s North American shale has continued its rebound from 2014 lows, coiled tubing has similarly grown in importance. Coiled tubing is facing new challenges, largely centred around the difficulty of horizontal wells with extended laterals as well as a wider variety of well paths and geological conditions in expanded drilling areas. This challenge is further impacted by the complicated logistics of coiled tubing operations, which require significant movement of heavy equipment. National Oilwell Varco (NOV), recognising that the changing landscape



of coiled tubing demanded new solutions, has been developing custom answers in response.

**Enhancements for existing equipment**

One issue surrounding coiled tubing equipment is retrofitting. It has become more common, across virtually all drilling- and completions-related capital equipment, to upgrade components and functionalities rather than purchase entirely new equipment, especially as companies remain cost-constrained and wary of unnecessary large purchases. The need for upgrades will be especially prevalent in 2019 and moving forward, as pressure pumping and coiled tubing fleets have largely been built out in 2018 on the back of the shale boom. Motley Services, a provider of well completion and intervention services

in the Permian Basin, is one company recognising the value of retrofitting. After purchasing an older coiled tubing unit at an auction, Motley approached NOV for the prospect of an overhaul. NOV completely stripped the unit and rebuilt it to like-new, including more advanced equipment and a larger control cabin. The unit was originally built for 2 in. coil, and after the upgrade it could handle 2½ in. coil. This meant that the unit could handle the larger coiled tubing necessary for longer, more difficult laterals – and that Motley Services was equipped to provide such services for their customers.



**Figure 1.** The first image in the sequence shows the original unit purchased by Motley Services, while the next two images show the unit overhauled by NOV and the new coiled tubing reel for larger spools.

## Logistical hurdles

Another issue for coiled tubing equipment has been the constraints of mobilising and operating the equipment in different jurisdictions where highway regulations typically differ substantially, thus restricting where the equipment is able to legally go. Copper Tip Energy Services, a Canadian well servicing provider offering coiled tubing, nitrogen pumping, and fluid pumping solutions, was looking to enhance their product offerings and add NOV coiled tubing equipment to their current large fleet of NOV-built nitrogen units. Unfavourable market conditions in Canada, primarily related to pipeline constraints and discounted oil prices resulting in reduced capital investment, presented Copper Tip with a less-than-ideal operating environment.

Recognising that several Canadian service companies were heading south of the border to take advantage of more lucrative market conditions, Copper Tip sought a way to move their equipment as well should conditions continue to decline. Unfortunately, moving such large equipment was not as simple as it sounds; allowable dimensions, weight, and axle/suspension configurations dictate whether or not something can be moved on standard roads. Without the ability to legally move equipment between Canada and the US, Copper Tip had little recourse other than the prospects of doing nothing or buying two separate units configured to the different countries' specs. A standard configuration in Canada is a 24 wheel, three-axle trailer suspension, while in the US the configuration is a 20 wheel, five-axle suspension. Neither of these are recognised in the other country, but it was impossible to justify purchasing two units, especially with the economic uncertainty of the Canadian unit, which might have to sit idle for a prolonged period. Faced with this dilemma, Copper Tip approached NOV to design a technology that would allow a unit to travel on both sides of the border, effectively changing the suspension to enable use in each location.

NOV developed a new coiled tubing unit that had the ability to interchange complete axle groups in a relatively short time and at a minimal cost to the operator. If it is necessary to relocate the coiled tubing unit, the alternate suspension/axle group – the one required by the country to which the unit is headed – is pinned into place, and the unit can cross the border safely and legally.

## Bringing together new equipment with training initiatives

Bridging the skills gap with new or upgraded equipment is another important component of optimising coiled tubing operations. Not having enough staff who can use the equipment effectively makes the investment worthless, an issue compounded by the financial loss and HSE concerns should an incident occur as a result of untrained staff. Balanced Energy Oilfield Services, Inc. is a coiled tubing operator in the western Canadian Sedimentary basin. With a desire to increase their market penetration in North America, the company needed to both add equipment that would be permissible in both markets, and hire and train new employees to meet higher demand expectations. Working with NOV, Balanced Energy was able to develop equipment specifications suited to both Canada and the US. In addition, they developed a complementary training programme to

reduce operational and service-related issues encountered with expansions.

Balanced Energy requested that NOV provide specific training on the coiled tubing equipment as it was delivered. One potential area for improvement was with coiled tubing injectors. The coiled tubing injector grips the tubing as it is inserted or pulled out of the well, and extremely high forces are required to control the tubing without damage to the injector or the tubing itself. In some instances, the coiled tubing could be a continuous piece of steel pipe in excess of 20 000 ft and valued at more than US\$200 000, making potential damage a major concern. Improper maintenance or operation of the injector could damage the tubing. After implementing new training practices created by NOV, Balanced Energy saw a significant reduction in service issues associated with both the coiled tubing injector and the coiled tubing. Improvement was so dramatic that the company requested additional training on other aspects of coiled tubing equipment and operation and, more broadly, various pieces of intervention and stimulation equipment.

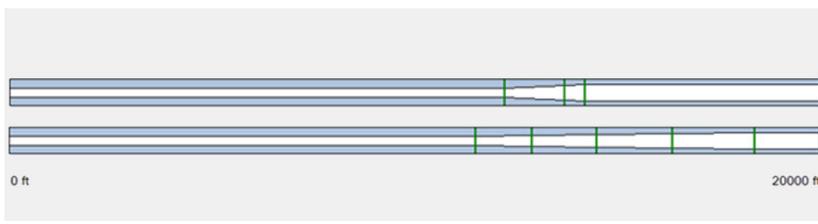
Balanced Energy found the injection operation training to be useful and saw good results from supervisors who were enforcing and following the new procedures. The technical background of the instructor, coupled with NOV's knowledge of the equipment as the OEM, was key.

### Optimised coiled tubing string design

Achieving success with coiled tubing operations depends not only on the equipment involved but also on the design of the



**Figure 2.** The new coiled tubing unit, designed to allow rapid change-out of suspension/axle groups to enable movement between countries.



**Figure 3.** On a previous project, NOV reduced the length of a 2% in. coiled tubing string design by approximately 64.5% when compared to a conventionally tapered design. The amount of taper sections was decreased from four to two, and the total average length of the tapers from 4315 ft to 1530 ft, with the TRUE-TAPER XR design.

coiled tubing itself. To optimise coiled tubing string design, NOV partnered with steel suppliers to develop TRUE-TAPER™ XR, an enhancement that is designed to minimise the number of bias welds in the tapered string and to assure a gauge-to-gauge bias weld in each instance. While traditional tapered strings have stress points at the bias weld juncture due to non-uniform load transfer, the TRUE-TAPER string achieves a linear taper by gradually varying the thickness of the flat steel strip over almost its entire length. This reduces stress concentrations and the number of bias welds while optimising strength-to-weight ratio and safety factors.

Pioneer Energy Services, a provider of coiled tubing services for well intervention and new well completion programmes, needed a product that would help them meet the challenges of longer laterals in unconventional shale. NOV provided Pioneer with the TRUE-TAPER XR. Pioneer initially developed string designs with XR tapers that could better overcome the weight restrictions of the Rockies, which were imposed by using a one-piece coiled unit and stricter DOT laws in the region. Given that acceptable pipe weight maximums were much lower, the new XR tapers allowed for hourglass string designs that had better reach and set-down weight in their well simulations versus non-XR taper designs. This increased performance allowed Pioneer to reach total depth on wells that were over 4 miles in measured depth and that could have 1 - 2 mile laterals. With non-XR designs, reaching the required depth would have been extremely difficult, if not impossible.

As horizontal wells with long laterals require heavy-wall tubing in the vertical section to go beyond the heel into the lateral, the string wall transition needs to go from heavy wall to light wall as quickly as possible to reduce the overall weight of the string. The XR tapers allowed Pioneer to maximise their string lengths while maintaining simulated performance levels and meeting strict weight requirements. In addition to completing projects with extended-reach laterals, the XR tapers also provided for greater string length. While without TRUE-TAPER XR the design would have resulted in a shorter string length, with them the string length could still be maintained for required well depths even as pipe was cut during normal string management.

### Looking forward

Due to the number of problems that can develop in producing wells, coiled tubing will remain a critical component of intervention solutions for the foreseeable future. As failing to address problems with producing wells could lead to a total loss of production over time, finding an appropriate intervention solution quickly is key. For many wells, the simplest considerations are well design versus solution economics – do they match, and is the solution financially feasible? Coiled tubing is frequently the answer due to how time-effective it is, and because it eliminates the typical costs of removing the tubing from the well via a workover rig. Combining the utility of coiled tubing with custom solutions to problems will help companies get ahead of the curve in this highly competitive, rapidly evolving market. ■